STATUS REPORT NO. 1 ON CLINCH RIVER STUDY

R. J. MORTON, EDITOR

Summary of First Status Report issued July 27, 1961

Objectives

The purpose of the study of the Clinch River below ORNL is to obtain data on the physical, chemical, and biological effects on a fresh water stream which receives large volumes of low-level radioactive waste. The program has four general objectives: (1) to determine the fate of the radioactive materials discharged to the Clinch River, (2) to determine and understand the mechanisms of dispersion of the radionuclides releases to the river, (3) to evaluate the direct or indirect hazards of current disposal practices in the river, and (4) to evaluate the over-all usefullness of this river for radioactive waste disposal purposes.

Description of Clinch and Tennessee Rivers

The Clinch River below Norris Dam is highly regulated by varying releases from the reservoir and by changes in the water level of Watts Bar Reservoir. The average flow of the river at Scarboro gage (CRM 39.0) is 4564 cfs. Maximum of 42,900 cfs and a minimum daily of 130 cfs. In summer, backwaters of Watts Bar Dam are warmer than the Clinch River water and stratification occurs. This commonly begins at CRM 12.6.

Contamination of community drinking water supplies is the most serious potential hazard that may result from discharges of radioactive materials in Clinch River. Estimated population of communities downstream from ORNL and served by surface-water sources on or adjacent to the Clinch and Tennessee Rivers is about 200,000. In 1955 it was estimated that there was more than 1000 irrigation installations in Tennessee, an increase in seven years of more than tenfold. Thus, the potential hazard of human exposure through food or

milk where radioactive contaminated water is used.

Use of Clinch River for Radioactive Waste Disposal

During the ten years, 1948-1957, approximately 3600 curies were discharged from White Oak Creek into the Clinch River. The major radioactive constituents in these wastes were the rare earths, Sr^{89}, Sr^{90}, Cs^{137}, and Ru^{106}.

The ORGDP and Y-12 Plants also discharge wastes to the Clinch River. These wastes are uranium and uranium-derived elements and although of low activity do increase the contamination load of the river.

Past and Present Water Monitoring Program

Liquid wastes from ORNL are continuously sampled daily in White Oak Creek, at White Oak Dam, and at ORGDP. The U. S. Geological Survey measures the amount of flow in White Oak Creek and in the Clinch River so that concentration of waste in the river can be determined.

The highest concentration of radioactivity in the river bottom sediment, except near the mouth of White Oak Creek, is about 18 times background and is located about 12 miles below the outfall of White Oak Creek. The concentration of radioactive materials in the river sediment falls off very quickly after the first twenty miles and is only about twice background at 100 miles and approaches background beyond Chattanooga at 150 miles downstream, though fission products are still detected by sediment analysis; however, it is difficult, if not impossible, to distinguish between fallout and waste disposal contaminants. The level of radioactive contaminants in the Tennessee River drops off rapidly below each dam because of water velocity and turbulence and increases again as the next dam approaches.

Sampling and Analysis

Water

During the first seven months of 1960 routine water sampling stations were established at the Oak Ridge Water Treatment Plant (CRM 41.5); at the ORGDP Water Treatment Plant (CRM 14.5); and at the Kingston Steam Plant, (CRM 3.8.) Data indicated that at the mouth of the Clinch River over 40% of the total activity carried downstream was Sr^{90}; and the percentages of Ru^{106} (23), Ce^{144} (13), Cs^{137} (13), Co^{60} (7), and $Zr\text{-}Nb^{95}$ (3) were 23, 13, 13, 7, and 3, respectively. Also these data indicated that approximately 70% of the Cesium was associated with the suspended sediments while only 5, 14, 22, 25, and 29% of Sr^{90} (5), Ru^{106} (14), Ce^{144} (22), Co^{60} (25), and $Zr\text{-}Nb^{95}$ (29), respectively, were associated with sediment. Based on the average sediment load of 27 ppm at the Oak Ridge Water Plant (upstream from White Oak Creek) the percentage of each isotope associated with suspended silt agreed quite well with the values predicted from laboratory studies of sorption by suspended and deposited sediments.

The data of special water studies of samples representing various river conditions, etc., have not yet been tabulated and made available.

Bottom Sediment

Aside from preliminary quarterly surveys, results shown in a previous report indicate no results are available as yet; although the collection of samples has been completed.

Annual surveys of radioactivity in bottom sediments of the Clinch and Tennessee Rivers have been made by ORNL since 1954. In the survey during the five-year period (1954-1958) reported by Cottrell, measurements were made at cross sections two miles apart in the Clinch River and ten miles apart in the Tennessee River. In the Clinch River, measurements were made at 50-foot intervals across the river at each cross section,

and in the Tennessee River 10 measurements were made at each cross section. The most striking result of these surveys is the demonstration of a significant increase in bottom radioactivity between 1955 and 1956, attributed to the draining of the White Oak Lake (October 1955) with the attendant scouring of the contaminated silt from the lake bottom.

Estimates of number of curies of six individual radionuclides indicated that in the Clinch River from the mouth of White Oak Creek the total number of curies deposited between mid-1943 and mid-1960 was approximately 1670. Of the principal radionuclides of interest, ruthenium-rhodium contributed 58% and cesium-barium 36% of the total radioactivity deposited in the Clinch River. In Watts Bar Reservoir from the mouth of the Clinch River to the Dam, it was estimated that 50 curies were deposited during the same 17-year period of which 38% was contributed by Ru^{106}, Rh^{106}, and 52% by Cs^{137}-Ba^{137}.

Biological Phases

Fish Population

In a preliminary hazard evaluation of Sr^{90} in fish based on fish samples taken from the Clinch River in February 1960, the expected human body burden of Sr^{90} which would result from the continuous consumption based on these species was estimated.

The Sr^{90} content of the flesh of eight individual fish used in the estimation was as follows:

Species	Location of Catch (CRM)	Sr^{90} Uμc/kg (Wet Weight)
White Bass	14.5	298
Sauger	14.5	115
Carp	14.5	340
Sauger	2.2	69
Small mouth bass	2.2	500
Small mouth buffalo	2.2	134
Carp	2.2	285
River Carpsucker	2.2	1030
Average concentration	2.2	346

It was assumed that 1/2 pound of fish constitutes a serving and that this quantity of fish would be eaten one a week by a human individual for a period of 50 years. Since the body burden from the continuous intake of Sr^{90} reaches 86% of its equilibrium value in 50 years, a human who ate one-half pound of fish every week for this period would have a body burden of 8.013×10^{-3} µc of Sr^{90}. The MAC in bone for occupational exposure is 2 µc and for the population at large 1/30 of this or 6.67×10^{-2} µc/ Thus, a member of the population at large eating these Clinch River fish would accumulate 12% of his maximum permissible body burden in 50 years or would have to increase his consumption of fish by a factor of 8.3 to attain his maximum permissible body burden in 50 years.

Radiation Effects on Biota

The salivary gland chromosomes of a blood worm common to the bottom of the White Oak Creek and Clinch River were studied in an attempt to describe the effects of chronic low-level radiation resulting from radioactive wastes on a natural population by sensitive cytogenetic methods. The high frequency of chromosomal aberrations in this insect larvae may be related to radioactivity and if this can be verified there is a possibility of establishing a field biological dosimeter.

Hydraulic Studies

Among special studies was the operation of continuous-discharge-record gaging stations on Bear Creek, East Fork Poplar Creek and Poplar Creek beginning in September 1960. No data of the hydraulic studies was given in this first status report.

GSH:la

8-14-61

fcc - waste disposal etc

UNION CARBIDE

INTERNAL CORRESPONDENCE

UNION CARBIDE NUCLEAR COMPANY • POST OFFICE BOX P, OAK RIDGE, TENNESSEE

To (Name) Mr. W. L. Richardson
Company
Location K-1001 Building

Date August 21, 1961
Originating Dept.
Answering letter date

Copy to

Subject Status Report No. 1 On Clinch River Study, R. J. Morton, Editor

The following appear to be highlights of interest to us from a gleaning of this first report:

1. Highest area of activity in Clinch is about 12 miles below White Oak Lake. At this point the radioactivity in the sediment is about 18 times background. This falls off rapidly after the first 20 miles and is only about 2 times background at 100 miles.

2. At the mouth of the Clinch about 40% of the total activity was due to Sr^{90} and the remaining radionuclides Ru^{106}, Ce^{144}, Cs^{137}, Co^{60}, and $Zr\text{-}Nb^{95}$ were 23, 13, 13, 7, and 3 respectively.

3. Except for the Cs^{137} (13% of total) relatively small amounts were detected in sediment indicating that sorption was not a major problem; about 70% of the Cs^{137} was accounted for in the sediment. It would appear from this preliminary observation that dilution in flowing water bodies provides a wide margin of safety.

4. Thus far uptake by fish does not appear to be of concern. The calculated dosage over a 50-year interval, assuming continuous intake of ½ pound/week, would yield only 12% of a permissible body burden.

5. A blood worm common to the river and White Oak Lake may provide an index of radioactivity since a study of the high frequency of chromosomal aberrations in this larvae indicate this may be related to radioactivity.

A F Becher

A. F. Becher
Safety and Health Physics Department